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U.S. Department
of Transportation

FEDERAL AVIATION ADMINISTRATION
Office of Aviation Policy and Plans

Washington, D.C. 20591

FAA-99-5925-2

PRELIMINARY REGULATORY EVALUATION, INITIAL REGULATORY FLEXIBILITY DETERMINATION, INTERNATIONAL TRADE IMPACT STATEMENT, AND UNFUNDED MANDATES ASSESSMENT

REDUCED VERTICAL SEPARATION MINIMUM OPERATIONS NOTICE OF PROPOSED RULEMAKING (14 CFR PART 91)

OFFICE OF AVIATION POLICY AND PLANS
OPERATIONS REGULATORY ANALYSIS BRANCH
JUNE 1999

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Executive Summary

This Notice of Proposed Rulemaking would establish airspace in the Pacific in which reduced vertical separation minimum may be applied. The existing Federal Aviation Regulations reduce the vertical separation minimum from 2,000 feet to 1,000 feet between flight level 290 and flight level 410 in certain designated airspace in the North Atlantic. This action is intended to do likewise in the Pacific, as well as enhance airspace capacity, permit operators to fly more fuel/time efficient tracks and altitudes, and enhance air traffic controller flexibility by increasing the number of available flight levels, while maintaining an equivalent level of safety.

The FAA estimates that this proposed rule would cost U.S. operators $21.7 million for the ten-year time period 2000-2009 or $19.5 million discounted. Estimated benefits, based on fuel savings for the commercial airplane fleet over the years 2000 to 2009, would be $120 million, $83.8 million discounted.

The FAA has determined that the amendments would not affect a substantial number of small entities. The proposed amendments would have no impact on international trade for either U.S. firms doing business overseas or foreign firms doing business in the United States. The FAA has determined that the requirements of Title II of the Unfunded Mandates Reform Act of 1995 do not apply to this rulemaking.

I. Introduction

This document contains a regulatory evaluation for a notice of proposed rulemaking (NPRM) to reduce the vertical separation minimum (RVSM) from 2,000 feet to 1,000 feet for airplanes operating between flight levels 29,000 (FL 290) and 41,000 (FL 410) in the Pacific airspace.

The proposed rule would impose additional aircraft and operator requirements. These requirements include: meeting the specified altimetry system error, having an automatic altitude keeping capability, and having an altitude alert system. These requirements must also be verified and maintained for RVSM operations in Pacific airspace. RVSM was successfully implemented in the North Atlantic (NAT) on March 27, 1997 and is scheduled for implementation in Pacific airspace in February 2000.

In addition to the regulatory evaluation, this document also contains an initial regulatory flexibility determination, which analyzes the economic effect of the proposed regulatory changes on small entities as required by the Regulatory Flexibility Act of 1980; an international trade impact statement, which is required by the Office of Management and Budget (OMB), and an unfunded mandate assessment, which is required by the Unfunded Mandates Reform Act of 1995.

II. History and Discussion of the NPRM

The appropriate amount of vertical separation standard above Flight Level 290 has been a matter of discussion since the mid-1950s. Originally, the vertical separation standard was 1,000 feet at all altitudes, and high altitude flight was possible for only a small number of military aircraft. Advances in technology eventually gave transport and general aviation aircraft the ability to operate at higher altitudes, resulting in increased traffic along high altitude route structures. In the 1950s, a vertical separation minimum of 2,000 feet was arbitrarily established between airplanes operating above FL 290. This minimum is specified in § 91.179 for continental U.S. airspace.

As the number of airplanes capable of operating at higher altitudes increased, competition for the higher altitudes also increased. This competition for the higher altitudes, together with worldwide fuel shortages and increasing fuel prices, sparked an interest in the early 1970s in implementing a reduced vertical separation minimum above FL 290. In 1973, the Air Transport Association (ATA) petitioned the Federal Aviation Administration (FAA) for a rule change to reduce the vertical separation minimum for aircraft operating above FL 290 to the original separation standard of 1,000 feet. The petition was denied in 1977 in part because (1) airplane altimeters had not improved sufficiently, (2) improved maintenance and operational standards had not been developed, and (3) altitude correction equipment was not available in all airplanes. In addition, the cost of re-equipping certain aircraft was considerable. On the basis of all available information, the FAA decided that granting the petition at that time will adversely affect safety.

Improvements in altimetry system performance, which began in the early 1970s, provided renewed impetus to reduce the vertical separation standard above FL 290. Air data computers provided an automatic means of correcting the known static source error which resulted in improved aircraft altitude-measurement performance. Altimeters were improved with enhanced transducers or double aneroids for computing altitudes. In addition, the advent of Mode C altitude data sent via a transponder, allowed air traffic control (ATC) with secondary surveillance radar to monitor flight levels.

Thus, in 1982, member States of the International Civil Organization's (ICAO) Reduced General Concept of Separation Panel initiated programs to study the feasibility of safely reducing the vertical separation minimum at and above FL 290. These programs included studies of precision radar data to analyze aircraft vertical performance, performance requirements necessary for safe implementation of a 1,000-foot vertical separation minimum above FL 290, and collision risk methodology to statistically evaluate the safety of future operations in a reduced separation environment. The results showed that the risk associated with operating in the RVSM environment (2.5 fatal accidents due to midair collisions, per billion flying hours or one midair collision every 100 to 150 years) will be acceptable. A further discussion of this is found Appendix A.

In conclusion, these improvements have provided renewed impetus to investigate reducing the vertical separation standard above FL 290 again.

III. The Proposed Rule

This proposed rule would revise part 91.706, appendix G, section 8 by permitting the reduction in vertical separation minimum from 2,000 feet to 1,000 feet above FL 290 up to and including FL 410 in designated Pacific airspace in addition to the NAT. The proposed rule would require airplanes and operators' equipment to be periodically verified and maintained for RVSM operations. The rule would also require additional aircraft to meet altimetry system error requirements, automatic altitude keeping requirements, and altitude alert system requirements to qualify for RVSM operations.

IV. Costs and Benefits

The analysis described in this regulatory evaluation is based on the following assumptions:

- All costs and benefits are presented in 1999 dollars.
- Projections of the current air carrier and general aviation fleet populations are current as of 1999.
- A discount rate of 7 percent is applied.
- Benefits and costs of RVSM implementation will begin to accrue in 2000.
- Airplane operator and ATC costs will begin to accrue in 2000; therefore, the lo-year period examined in this regulatory evaluation is 2000 through 2009.
- The implementation plan may call for phasing in RVSM initially only on a limited number of flight levels. However, this analysis assumes that there will be no phased implementation period.

A. Costs

The cost of the following elements of RVSM implementation will be considered:

- Aircraft Airworthiness Approval

- Monitoring
- ATC

1. Aircraft Airworthiness Approval Costs

Under the proposed rule, Pacific operators seeking RVSM approval, would be required to ensure that their airplanes meet various equipment and altimetry system requirements. These requirements are contained in manufacturers' service bulletins that have been developed for each specific airplane type. The estimated costs associated with these requirements are grouped by airplane types for both commercial and general aviation (GA) aircraft (See Table 1).

Table 1. Manufactures' Service Bulletin Completion Costs				
Type	Series	Estimate	Source	Comments
B747	100/200	$ 58,373	FAA Survey 12/97 and Oceanic Working Group (OWG) Survey 6/97	
B747	400	$ 33.333	OWG Survev 6/97	
B757		$ 50,714	FAA Survey 12/97 and OWG Survey 6/97	
DC10		$ 2,235	OWG Survey 6197	
MD11		$ 2,235	Engineering analysis, same as DC10	
DC8		$285,714	FAA Survey 12/97	
L101		$ 20.000	OWG Survev 6/97	
B767		$ -	Manufacturer	Visual inspection only
B777		$ -	Manufacturer	Visual inspection only
A300		$ -	Manufacturer	Visual inspection only
A330		$ -	Manufacturer	Visual inspection only
A340		$ -	Manufacturer	Visual insoection onlv
CL60	1A	$ 62,500.00	Manufacturer	
CL60	3A/3R	$ 17,500.00	Manufacturer	
CL60	604	S -	Manufacturer	
GULF	G4	$ 14,000.00	Manufacturer	
GULF	G3	$ 14,000.00	Manufacturer	S/N 427 and higher
GULF	G3	$197,000.00	FAA Survey 12/97	S/N 426 and lower
GULF	G2	$189.500.00	Manufacturer	
F2TH		$ 15,000.00	Manufacturer	
F900		$ 15,000.00	Manufacturer	
FA50		$200,000.00	Manufacturer	
FA20		$ 15.000.00	Manufacturer	
H25B		$ 19,000.00	Manufacturer	
LJ60		$ 13,000.00	Manufacturer	
C750		$ 0.00	Manufacturer	
C650		$ 22.000.00	Manufacturer	

These estimates represent the cost of the engineering work associated with making an airplane RVSM compliant or the airworthiness approval cost.

It is necessary to determine the actual operators and airplane types for the Pacific airspace because many US operators already have RVSM approval for some of their airplanes for the NAT. In addition, some commercial operators conduct operations in both the NAT and the Pacific while others have separate fleets of aircraft that operate in one geographic region. Since general aviation operators do not operate scheduled routes, many have been approved for RVSM operations on the basis of actual or potential NAT flights.

To determine the number of U.S. operators in the Pacific and the type of airplanes they operate, a sample of the FAA's Enhanced Traffic Management System (ETMS) data from Pacific oceanic airspace was studied. ETMS data is comprised of actual aircraft traffic data that identifies operators, aircraft types, and the frequency of operations. For the US commercial carriers, the Pacific operators and airplane type information from ETMS data was combined with projected airplane fleet data from an FAA Pacific RVSM survey and approved NAT aircraft data from the NAT Central Monitoring Agency (CMA). The results of this analysis provide the number of operators and airplanes that need to be airworthiness approved or upgraded for RVSM, by aircraft type, for each US Pacific operator (See Table 2).

Table 2. Commercial Aircraft Upgrade Costs									
Airline/Operator	AC Type	AC Series	Total Fleet Size	Oper in PAC	Future Oper in PAC	RVSM Approved	To Upgrade	$ per A/C	Total
American Airlines	B757	200 ER	6	6	8	0	6	$ 50,714.29	$ 304,285.71
	DC10		18	18	16	0	18	$ 2,235.29	$ 40,235.29
	MD11		19	6	7	19	0		
American Trans Air	B757		8	6	6	8	0		
	L1011		14	3	3	13	0		
American International	B747	100/200	9	9	9	2	7	$ 58,373.11	$ 408,611.74
	L1011		6	6	6	2	4	$ 20,000.00	$ 80,000.00
Continental	B747	100/200	4	4	4	0	4	$ 58,373.11	$ 233,492.42
	DC10	30	30	3	3	30	0		
Delta Airlines	L1011	250	23	23	23	5	18	$ 20,000.00	$ 360,000.00
	MD11		15	8	8	15	0		
DHL Worldwide Express	DC8	73	7	7	7	0	7	$285,714.29	$ 2,000,000.00
Evergreen International	8747	1001200	11	11	11	9	2	$ 58,373.11	$ 116,746.21
FedEx Corp	DC10	30	22	22	22	21	1	$ 2,235.29	$ 2,235.29
	MD11		38	38	38	22	16	$ 2,235.29	$ 35,764.64
Gemini	DC10	30	6	6	6	0	6	$ 2,235.29	$ 13,411.76
Atlas Air	B747	200	22	22	22	10	12	$ 58,373.11	$ 700,477.27
Hawaiian Airlines	DC10	DC10	10	10	11	0	10	$ 2,235.29	$ 22,352.94
Northwest Airlines	B747	400	10	10	12	10	0		

Table 2. Commercial Aircraft Upgrade Costs

Airline/Operator	AC Type	AC Series	Total Fleet Size	Oper in PAC	Future Oper in PAC	RVSM Approved	To Upgrade	$ per A/C	Total
	B747	100/200	33	33	33	2	3	1 $ 58,373.11	$ 1,809,566.29
	DC10	30	37	37	37	35	2	$ 2,235.29	$ 4,470.59
Polar Air Cargo	8747	100	16	16	14	13	1	$ 58,373.11	$ 58,373.11
Trans World Airlines	B757	200	15	15	16	15	0		
	B767	300	3	3	3	3	0		
United Airlines	B747	400	31	31	41	32	0	$ 33,333.33	$
	B747	200	9	9	7	0	7	$ 58,373.11	$ 408,611.74
	B757	200	92	10	30	0	30	$ 50,714.29	$ 1,521,428.57
	DC10		33	33	13	0	13	$ 2,235.29	$ 29,058.82
United Parcel Service	B747	100	14	3	6	16	0	$ 58,373.11	$ -
	B757	200	70	0	3	0	3	$ 50,714.29	$ 152,142.86
	B767	300	30	0	4	30	0		
	DC8	73	26	3	0	0	0	$285,714.29	$ -
World Airlines	DC10	30	3	3	3	3	0	$ 2,235.29	
	MD11		9	9	9	8	1	$ 2,235.29	$ 2,235.29
Total			699	423	441	323	199		$ 8,303,500.57

As previously mentioned, many GA operators have been approved for RVSM operations on the basis of actual or potential NAT flights. Of the GA aircraft capable of RVSM operations in the Pacific, there were 903 airworthiness approved for RVSM for the NAT as of 7 May 1999 (See Table 3).

Table 3. General Aviation Airplanes Upgrade Costs

A/C	US Registered	NAT Approved	Months of Service Bulletin	% Approved per month	50% of 6/99-2/01	Cost per A/C	Total
CL60	298	221	24	3%	39	$62,500	$2,406,250
LJ60	116	24	22	1%	11	$13,000	$148,909
GULF G4	279	232	22	4%	24	$14,000	$329,000
GULF G3*	48	41	10	9%	4	$14,000	$49,000
GULF G3**	92	15	10	2%	16	$197,000	$3,102,750
F2TH	46	37	24	3%	5	$15,000	$67,500
F900	107	107	24	4%	0	$15,000	$0
FA50	169	113	24	3%	28	$200,000	$5,600,000
FA20	24	12	24	2%	5	$15,000	$78,750
H25B	198	50	16	2%	33	$19,000	$623,438
ASTR	81	6	11	1%	6	$20,000	$114,545
C750	69	33	17	3%	20	$0	$0
C650	265	12	17	0%	7	$22,000	$163,059
TOTAL	1792	903	245		197		$12,683,201

* Serial # 427 and higher
** Serial # 426 and lower

It is projected that GA operators would start seeking approval for Pacific operations in June 1999 (Pacific RVSM Task Force Project Plan). Operators approval experience gained during the NAT RVSM implementation has shown that GA operators would seek RVSM approval after service bulletins are released for their airplanes regardless of what airspace they operate in[1]. GA operators would seek approval in order to have the flexibility to operate in any airspace where RVSM has been applied. In other words, GA operators would seek approval for RVSM operations in order to have the flight planning flexibility that RVSM offers, not specifically because operations are planned in RVSM airspace. To account for those airplanes seeking approval for NAT operations, the current observed NAT aircraft approval rate for each aircraft type can be applied for the period June 1999 to February 2001 (See Table 3). It is estimated that airplanes would be approved specifically for Pacific RVSM operations during the period from June 1999 to February 2001. The number of these Pacific approvals would be 50% of the observed aircraft approval rate for each aircraft type or half of the remaining unapproved aircraft population.

Any maintenance associated with maintaining aircraft readiness to operate in the RVSM environment would be part of the currently established maintenance/continuous airworthiness program for an operator as documented in the individual airplane service bulletin. There would be no added cost.

Operational program requirements include flight crew training to ensure familiarity with RVSM operations. Such training would be conducted through the publication and distribution of an RVSM

[1] GPS-Based Monitoring System Operations Coordinator February

bulletin. The cost of the bulletin is estimated to be $500 for each operator or $107,000 for 17 commercial and 197 GA operators.

2. Monitoring Costs

In 1988, the ICAO Reduced General Concept of Separation Panel (RGCSP) agreed that the target level of safety (TLS) should be 2.5 fatal accidents due to midair collisions in 10^9 flying hours (or approximately one midair collision every 100 to 150 years) for determining equipment requirements.' To ensure that the TLS is not exceeded, it is necessary to monitor the occurrence of total vertical error (TVE) and other parameters that are critical to safety assessment (e.g., lateral and longitudinal overlap probability). A monitoring system has been developed to monitor TVE and produce estimates of aircraft and flight level geometric height.

The Pacific monitoring program would use the global positioning system (GPS)-based monitoring system (GMS) that was developed for NAT RVSM operations by the FAA. A CMA would also be required to oversee the monitoring system and determine the overall height-keeping performance of airplanes operating in the Pacific.

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[2] ICAO, RGSP. Review of the General Concept of Separation Panel, 6th Meeting. Volume 1, December 1988, ICAO Doc. 9536, RGSCP/6.

At present, the GMS staff is monitoring approximately 40 airplanes per month at a cost of $120,000 per month or $3,000 per airplane (GMS Technical Manager estimate). The Pacific monitoring goals can be summarized as follows:

- For operators with prior RVSM experience: 2 airplanes of each type are required to be monitored.
- For operators with no prior RVSM experience: 3 airplanes of each type are required to be monitored.

Applying the monitoring goals to the Pacific commercial airplane fleets determined from traffic analysis yields the estimate contained in Table 4. The GA operators' monitoring estimate in Table 4 is the number of airplanes estimated to be upgraded for Pacific operations from Table 3.

Table 4. RVSM Monitoring Estimate						
Airline/Operator	AC Type	AC Series	Future Operations in PAC	Monitored From NAT	Monitoring Req.	Cost @ $3K each
American Airlines	B757	200 ER	8	0	2	$6,000
	DC10		16	0	2	$6,000
	MD11		7	19		$0
American Trans Air	B757			8		$0
	L1011		3	11		$0
American International	B747	100/200		0	2	$6,000
	L1011			2		$0
Continental	B747	100/200		0	2	$6,000
	DC10	30	3	28		$0
Delta Airlines	L1011	250		5		$0
	MD11			15		$0
DHL Worldwide Express	DC8	73	7	0	3	$9,000
Evergreen International	B747	100/200		9		$0
FedEx Corp	DC10	30		18		$0
	MD11			21		$0
Gemini	DC10	30		0	3	$9,000
Atlas Air	B747	200		10		$0
Hawaiian Airlines	DC10	DC10	11	0	3	$9,000
Northwest Airlines	B747	400	12	10		$0
	B747	100/200	33	0	2	$6,000
	DC10	30	37	24		$0
Polar Air Cargo	B747	100	14	11		$0
Trans World Airlines	B757	200	16	4		$0
	B767	300	3	3		$0
United Airlines	B747	400	41	17		$0
	B747	200	7	0	2	$6,000
	B757	200	30	0	2	$6,000
	DC10		13	0	2	$6,000
United Parcel Service	B747	100	6	13	2	$6,000
	B757	200	3	0	2	$6,000
	B767	300	4	6		$0
	DC8	73	0	0	0	$0
World	DC10	30		3		$0
	MD11			7		$0
General Aviation					197	$591,000
Total					226	$678,000

The cost to complete the monitoring of the U.S. Pacific airplane fleet will be $678,000 in 1999 dollars.

A CMA would be responsible for coordinating with ICAO member states and tracking the overall performance of the monitoring system. The FAA's William J. Hughes Technical Center would fulfill this function on behalf of ICAO. The total monitoring cost over 15 years is $678,000 or $664,982 discounted.

3. <u>Air Traffic Control Costs</u>

RVSM implementation in the NAT has shown that controller workload will decrease and training for RVSM can be accomplished during the existing training cycle. Air traffic control would experience no additional cost in implementing RVSM in the Pacific.

<u>Summary of RVSM Implementation Costs</u>

Based on NAT experience, it is expected that the airworthiness approval implementation costs for the commercial carriers would occur as follows:

- 80% of costs 1 year prior to implementation
- 20% of costs 1 year after implementation

It is also expected that 80% of the monitoring costs associated with implementation would occur in the year prior to implementation and 10% would occur in each year after implementation. For GA aircraft, the costs are expected to occur in equal amounts 1 year prior to, 1 year after, and 2 years after implementation. The training costs are expected in the year prior to implementation. The FAA estimates that the total cost is $21.7 million or $19.5 million discounted over 10 years (See Table 5).

Table 5. Implementation Costs							
	Commercial A/C Upgrade	GA A/C Upgrade	Total Upgrade	Training/ Monitoring	Total	Discount Rate Factor @ 7%	Discounted Total
2000	$6,642,800	$4,227,733	$10,870,533	$649,400	$11,519,933	0.935	$10,771,137
2001	$1,660,700	$4,227,733	$5,888,433	$67,800	$5,956,233	0.873	$5,199,791
2002		$4,227,733	$4,227,733	$67,800	$4,295,533	0.816	$3,505,155
2003						0.763	
2004						0.713	
2005						0.666	
2006						0.623	
2007						0.582	
2008						0.544	
2009						0.509	
Total	$8,303,500	$12,683,201	$20,986,699	$785,000	$21,771,699		$19,476,083

B. Benefits

The FAA concludes that implementing RVSM would offer operational benefits to operators. A detailed discussion of how safety is maintained is discussed in Appendix A. Estimated benefits, based on fuel savings for the commercial airplane fleet over the years 2000 to 2009, would be $120 million, $83.8 million discounted.

Fuel Savings

The greater availability of fuel-efficient altitudes and the utilization of efficient cruise climbs will yield fuel savings for commercial operators. No quantifiable benefits are assumed for GA aircraft operators since they typically get their optimum altitude in the current system. To calculate the quantifiable benefits of improved fuel consumption, The MITRE Corporation completed a study of RVSM benefits that estimated the daily fuel savings for all U.S carriers in the Pacific region to be 49,048 gallons. The study is documented in Appendix B. Total annual savings presented in Table 6 were determined by multiplying the product of the daily fuel savings, 49,048 gallons, and 365 days, by the international jet fuel price of $0.68 per gallon (U.S. Department of Transportation, Federal Aviation Administration. FAA Aviation Forecasts Fiscal Years 1999-2008) In order to account for the February 24, 2000 implementation date, 310 days was used to calculate the savings for 2000.

Table 6. Fuel Savings			
	Annual Fuel Savinas	Discount Rate Factor @ 7%	Discounted Total
2000	$10,339,318	0.935	$9,667,262
2001	$12,173,714	0.873	$10,627,652
2002	$12,173,714	0.816	$9,933,751
2003	$12,173,714	0.763	$9,288,544
2004	$12,173,714	0.713	$8,679,858
2005	$12,173,714	0.666	$8,107,694
2006	$12,173,714	0.623	$7,584,224
2007	$12,173,714	0.582	$7,085,102
2008	$12,173,714	0.544	$6,622,500
2009	$12,173,714	0.509	$6,196,420
Total	$119,902,744		$83,793,007

V. Costs-Benefits comp[redacted]

The FAA estimates that this proposed rule would cost U.S. operators $21.7 million for the ten-year time period 2000-2009 or $19.5 million, discounted. Estimated benefits, based on fuel savings for the commercial aircraft fleet over the years 2000 to 2009 would be $120 million, $83.8 million discounted.

VI. Initial Regulatory Flexibility Determination

The Regulatory Flexibility Act of 1980 establishes " as a principle of regulatory issuance that agencies shall endeavor, consistent with the objective of the rule and of applicable statues, to fit regulatory and informational requirements to the scale of the business, organizations, and governmental jurisdictions subject to regulation." To achieve that principle, the Act requires agencies to solicit and consider flexible regulatory proposals and to explain the rational for their actions. The Act covers a wide-range of small entities, including small businesses, not-for-profit organizations and small governmental jurisdictions.

Agencies must perform a review to determine whether a proposed or final rule will have significant economic impact on a substantial number of small entities. If the determination is that it will, the agency must prepare a regulatory flexibility analysis (RFA) as described in the Act.

However, if an agency determines that a proposed or final rule is not expected to have a significant economic impact on a substantial number of small entities, section 605(b) of the 1980 act provides that the head of the agency may so certify and an RFA is not required. The certification must include a statement providing the factual basis for this determination, and the reasoning should be clear.

A review of the Pacific traffic data shows that no small entities operate in Pacific oceanic airspace where this rule applies. The FAA has also examined the impact of this rulemaking on small operators of general aviation aircraft. The FAA data base of U.S. registered aircraft operators shows that these airplanes are all operated by commuter or air taxi operators. Commuter or air taxi operators do not operate in Pacific oceanic airspace.

The FAA has determined that there are reasonable and adequate means to accommodate the transition to RVSM requirements, particularly for general aviation operators (many of whom are small). As of May 1999, 50% of the U.S registered GA aircraft were approved for RVSM operations based on the NAT application of RVSM.

The FAA conducted the required review of this proposal and determined that it would not have a significant economic impact on a substantial number of small entities. Accordingly, pursuant to the Regulatory Flexibility Act, 5 U.S.C. 605(b), the Federal Aviation Administration certifies that this rule would not have a significant impact on a substantial number of small entities.

VII. International Trade Impact Statement

The provisions of this proposed rule would have little or no impact on trade for U.S. firms doing business in foreign countries and foreign firms doing business in the United States.

VIII. Unfunded Mandates Assessment

Title II of the Unfunded Mandates Reform Act of 1995 (the Act), enacted as Pub. L. 104-4 on March 22, 1995, requires each Federal agency, to the extent permitted by law, to prepare a written assessment of the effects of any Federal mandate in a proposed or final agency rule that may result in the expenditure by State, local, and tribal governments, in the aggregate, or by the private sector, of $100 million or more (adjusted annually for inflation) in any one year. Section 204(a) of the Act, 2 U.S.C. 1534(a), requires the Federal agency to develop an effective process to permit timely input by elected officers (or their designees) of State, local, and tribal governments on a proposed "significant intergovernmental mandate." A "significant intergovernmental mandate" under the Act is any provision in a

Federal agency regulation that would impose an enforceable duty upon State, local, and tribal governments, in the aggregate, of $100 million (adjusted annually for inflation) in any one year. Section 203 of the Act, 2 U.S.C. 1533, which supplements section 204(a), provides that before establishing any regulatory requirements that might significantly or uniquely affect small governments, the agency shall have developed a plan that, among other things, provides for notice to potentially affected small governments, if any, and for a meaningful and timely opportunity to provide input in the development of regulatory proposals.

This proposed rule does not contain a Federal intergovernmental and private sector mandate that exceeds $100 million a year, therefore, the requirements of the act do not apply.

APPENDIX A

Safety Benefits Analysis

The Federal Aviation Administration William J. Hughes Technical Center measured the change of safety by using work developed by North Atlantic Systems Planning Group (NATSPG) and International Civil Aviation Organization's (ICAO) Reduced General Concept of Separation Panel (RGCSP).[3] They used the Reich[4] collision risk model, which expresses risk in terms of specific quantifiable parameters. A detailed description of the model is found in the Pacific RVSM Guidance Material

The basic element of the risk evaluation method is the target level of safety (TLS), which expresses the level of risk deemed acceptable. The TLS is an index against which the calculated risk can be compared to help determine if operations in the airway system under consideration are safe. The TLS for this application represents the expected number of fatal accidents per aircraft flight hour in a given airway system due to decreased vertical separation between aircraft at adjacent flight levels. Because separation standards are meant to control fatal accidents, the TLS is expressed in

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[3] See Review Of the General Concept of Separation Panel 6th Meeting Volume 2, December 1988, ICAO Doc. 9536, RGCSP/6.

[4] See Pacific RVSM Guidance Material, January, 1999

units of fatal accidents rather than the severity of the fatal accident.

The current TLS of 2 fatal accidents per 100 million flight hours has been used in the Minimum Navigation Performance Specification airspace since the late 1970s.[5] The Pacific Guidance Material states that through examination of U.S. accident data and related information, such as historical data, midair collision data, and near-midair collision data, a regional TLS of 2.5 fatal accidents in 1,000 million flying hours resulting from 1,000-ft vertical separation was established with the required equipment. This TLS is an order of magnitude more stringent than the current level. Therefore, it was determined that the risk associated with operating in the RVSM environment will be acceptable.

The method described for implementing this 1,000-foot vertical separation standard was based on collision risk modeling and an accepted level of safety. A period of 100 to 150 years between midair collisions is considered acceptable in high-density traffic areas. If the same separation standard were applied to the North Atlantic airspace, where traffic density is relatively low, the standard theoretically could result in a period of approximately 700 years between midair collisions.

[5] Brooker, P., and Ingham, T., Target Levels Of Safety for Controlled Airspace, CAA Paper 77002, February 1977.

APPENDIX B

MP 98W0000270

MITRE PAPER

Projected Reduced Vertical Separation Minimum (RVSM) Benefits for U.S. Air Carriers in the Pacific Region

December 1998

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sponsor:	Federal Aviation Administration	Contract No.:	DTFAOI-C-93-00001
Dept. No.:	F047	Project No.:	**02991205-03**

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Abstract

This document is intended to support the Federal Aviation Administration (FAA) Rulemaking Process for Reduced Vertical Separation Minimum (RVSM) implementation in the Pacific. The FAA plans to implement RVSM in the Pacific Region on 24 February 2000. Oakland and Anchorage Air Route Traffic Control Centers (ARTCCs) are the two U.S. facilities that would be affected by this implementation. The purpose of this report is to document the analysis of projected RVSM benefits for U.S. air carriers and to identify potential implementation issues that need further examination.

KEYWORDS: Oceanic, Separation, RVSM, Benefits, Approved RVSM Aircraft, Non-approved RVSM Aircraft, Benefits Analysis, Fuel Penalties, Fuel Savings

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Section 1

Introduction

In the FAA's Strategic Plan for Oceanic Airspace Enhancements and Separation Reductions [1], RVSM implementation in the Pacific is identified as a high priority separation initiative with a planned implementation of 24 February 2000. This plan describes the FAA's high level strategy to support the overall Oceanic Air Traffic Management (ATM) System improvements, while the Management Plan and Implementation Plans describe the lower level activities and the specific implementation details. In order to implement any separation reduction in oceanic airspace, the International Civil Aviation Organization (ICAO), through a cooperative process, must establish the standards and recommend procedures (e.g., Doc 7030,) that will be applicable in the designated airspace regions. The ICAO guidelines for RVSM in the Pacific have been drafted and if adopted by the member states, the U.S. would be responsible for RVSM application in its allocated airspace. In order to realize the potential benefits of RVSM, it is imperative that Civil Aviation Authorities (CAAs) responsible for neighboring Flight Information Regions (FIRs) in the Pacific have common or complementary RVSM operations, In addition, the air carriers must understand the impact to their operations and ensure that the planned RVSM operations are consistent with expectations.

1.1 Background

The FAA plans to implement RVSM in the Pacific on 24 February 2000 from FL 310 through FL 390 for approved aircraft throughout the Oakland and Anchorage oceanic FIRs. The ultimate goal is to increase the number of available flight levels, enhance airspace capacity, permit operators to fly more fuel/time efficient tracks and altitudes, and enhance Air Traffic Control (ATC) flexibility in crossing situations and in responding to pilot requests. Other benefits include the ability for flights to enter oceanic airspace at more efficient altitudes, reduction in speed control measures to separate aircraft, availability of added track flight levels, increased controller flexibility to clear aircraft for more efficient step climbs, and increased controller flexibility to route aircraft to appropriate tracks.

This benefits analysis is predicated on a set of assumptions for how RVSM could be implemented in the U.S. FIR. Any change to these assumptions could impact the results of the benefits analysis. Recent developments have indicated that other implementation strategies are under consideration including the addition of flight levels for track loading and a phased application by geographical sub-divisions (e.g., North Pacific [NOPAC], Central East Pacific [CEP], Central Pacific [CENPAC], South Pacific [SOPAC]). The basis for some of these other alternatives are rooted in current, unresolved issues (e.g., RNP-10 in the

CEP, use of additional altitudes). An assessment of these other alternatives will be necessary to identify the impact to user benefits as well as ATC operations. It is important to recognize that the potential benefits of RVSM in the Pacific are dependent on developing complementary implementation strategies with neighboring FIRs.

1.2 Scope

In support of the U.S. Rulemaking Process, an analysis is needed of the projected benefits to U.S. air carriers with regard to the implementation of RVSM in the Pacific. Rulemaking allows for early buy-in from all involved parties, policy setting, establishment of priorities, and resolution of issues. Since the implementation strategy will exclude non-approved RVSM aircraft from filing a flight plan between Flight Level (FL) 310 and FL 390 in RVSM designated airspace, it is important that these users understand the impact to their operations. For the purpose of conducting a benefits analysis for U.S. air carriers throughout the oceanic FIRs, it was assumed that the neighboring FIRs would implement RVSM in the same manner as proposed by the U.S.

The data collected to date indicates that 98 percent of the flights operated by U.S. air carriers in the Pacific will be approved for RVSM by February 2000 [2]. U.S. air carriers are anticipating that the RVSM benefits in the Pacific will be similar to those achieved in North Atlantic (NAT). It is important to note that the actual benefits realized by U.S. air carriers will depend on the specific use of RVSM in the Pacific.

This paper presents the benefits analysis of RVSM implementation in the Pacific for U.S. air carriers based on a set of baseline assumptions identified in Section 2.2 regarding a particular implementation strategy. It is important to note these implementation assumptions do not fully support the ultimate RVSM goals identified in Section 1.1 and would require further analysis.

The results of the benefits analysis are quantified in terms of flying time saved, (i.e., delay reductions), fuel savings, fuel penalties, and opportunities for additional step climbs. The benefits are measured along the route of flight throughout the entire oceanic airspace (i.e., U.S. FIR oceanic airspace and Foreign FIR oceanic airspace). These benefits are driven by the specific application of RVSM as assumed in the analysis. The impact to U.S. Military, U.S. General Aviation, and Foreign Carriers are excluded from this particular benefits analysis.

Section 2
Benefits Analysis

The following sections provide the approach and set of assumptions used to conduct the RVSM benefits analysis for U.S. air carriers that operate in the Pacific Region.

2.1 Approach

This section describes the approach used to conduct the benefits analysis, including the data used for the analysis and a description of the Center for Advanced Aviation System Development (CAASD) fuel bum model and associated pre and post processing of data. Benefits, as well as penalties, were determined based on a set of criteria regarding fuel usage, step climbs, and delays under pre-RVSM and post-RVSM conditions. These parameters were estimated based upon an analysis of the results from previous oceanic benefit studies that utilized the CAASD oceanic implementation of the FAA fuel bum model. The flight paths of aircraft utilized in the model have typically been based on actual position reports extracted from Oceanic Display and Planning System (ODAPS) System Analysis Recording (SAR) data. The intent of this analysis, however, required that the benefits be calculated not only through the U.S. oceanic FIR but throughout the entire oceanic airspace which includes foreign FIRs.

Since ODAPS does not have the position data for aircraft outside of its airspace, there would not be sufficient information to determine the full oceanic flight paths. Also, for aircraft that did not traverse Oakland airspace, there would not be any data in the Oakland ODAPS database. Since no equivalent data was directly available from the Anchorage Offshore Computing System, it was determined that Enhanced Traffic Management System (ETMS) recorded data would be utilized to account for those flights in the Pacific.

A significant change was made to the model that allowed for the creation of flight trajectories from flight plan information as opposed to position reports. In order to accomplish this, a significant number of fixes and lat/longs had to be defined for purposes of creating the trajectory. It is recognized that the filed flight plan may not represent the actual path taken by the aircraft. However, for purposes of this analysis, the flight plan offered the best source of data and does reflect the original preferred route. Aircraft that do not traverse either Oakland or Anchorage airspace were not included in the simulation due to lack of data. Altitude profiles, when available in the tiled flight plan, were used in simulating the path of the aircraft. When altitude profiles were not contained in the flight plan, a reasonable profile was manually inserted based on projected weight and optimum profile. Specific weights for each flight were not available and had to be estimated based on an assumed maximum weight (for the general aircraft type) adjusted for the flight time from the origin airport to the oceanic entry fix.

ATC operations as denoted through tiled flight plans, were examined for the dates listed below.

- 10, 18 and 25 May 1998
- 10, 22, 23 and 25 July 1998

The original plan was to examine traffic data for several days in January 1998 rather than May 1998, in order to account for seasonal variations of the traffic flows. However, during the process of extracting January ETMS flight data for Anchorage, it was realized that the data did not reflect current operations on the NOPAC tracks. The reason for this difference was that RNP- 10 had not yet been implemented in January. Because some of the traffic flows changed as a result, it was necessary to forgo the January data in order to analyze traffic flows that represented current ATC operations. The May dates were selected as a reasonable compromise that offered the earliest use of data while providing some time to allow traffic and procedures to settle after RNP- 10 implementation on 23 April 1998.

Flight plan data was extracted for seven days from ODAPS SAR data for Oakland (ZOA) and for two days from ETMS data for Anchorage (ZAN). Due to various problems with extracting ETMS data, only 18 May and 25 July data were utilized to account for ZAN traffic. It was necessary to use the one day in May as representative of the other two days in May and the one day in July as representative of the other three days in July.

Wind data was only available for Oakland airspace for the selected days. Wind data for Anchorage and Japanese airspace could not be obtained. In order to determine whether this would significantly affect the results the fuel bum model, the model was run with and without wind data for RVSM and no RVSM conditions. The results of this showed a negligible difference and therefore, wind information was not factored into the simulation. As a side note, a wind speed difference of one knot will vary the fuel bum for a seven hour flight by 40 gallons.

The CAASD fuel bum model consists of two functional parts: fuel computation and flight simulation. The fuel computation is based on a set of equations to determine the effect of thrust, drag, weight, etc., on fuel consumption. The coefficients of each aircraft type must be provided to the model as well as each aircraft's weight, speed, and altitude. The flight simulation is based on a simple queuing model of a matrix of fixes and aircraft flying from fix to fix. The simulation provides conflict-free paths for organizing traffic flows by assuring appropriate separation at the merging and crossing fixes. The simulation uses longitudinal separation to space aircraft along a common path where only one aircraft is allowed to occupy an altitude at a given fix. The model does not employ Mach separation procedures.

At each point where routes merge or intersect, lateral separation between aircraft is employed. The model converts distance-based lateral separation into an effective time separation at such points and is only capable of handling one separation rule. For purposes of this analysis, the lateral separation rule was 50 nmi which assumes that all involved aircraft are RNP-IO approved. Predicted arrival time differences are compared to the desired effective time separation at that point, assuming that aircraft maintain their desired paths, If it is projected that the required separation will be violated, then the second flight is delayed to resolve the conflict. This action would equate to a speed control measure or crossing restriction imposed by the controller. Since this does not necessarily reflect how the controller would handle this situation, these instances are independently reviewed and an assessment is made regarding whether the effect is significant. If the determination is that an ATC maneuver would more likely be applied to resolve the conflict, then a manual change is made to the flight trajectory and the model is run using the modified flight data.

In the vertical dimension, if an aircraft requests a step climb to an altitude that leads to a conflict, a delay is imposed on the aircraft in order to allow the step climb. If an aircraft would be in conflict after a step climb and a lower altitude is available, then the aircraft is climbed one step at each fix until it can climb no higher without a conflict. It is then delayed until it can achieve the desired altitude. Again, this action would equate to a controller imposed speed control measure, but may not necessarily reflect how a controller would handle the situation. These situations are individually assessed and if required, a manual adjustment is made to the flight trajectory. The model is then rerun using the modified flight information. In cases where the trajectory change would not affect any other aircraft flowing behind or below the flight in question, corrections for the affect of a flight profile change can be made during the post processing.

For purposes of simplifying the model, climbs and descents are permitted only at fixes, and not at intermediate points along the route. In reality, aircraft climbs do occur at points other than fixes, but the tendency is for these climbs to be highly clustered around fixes. In addition, climb requests at intermediate points not contained in the flight plan were not injected or modeled for either run since these climb requests are based on a number of factors (e.g., pilot concerns regarding weather) that are not predictable.

2.2 Baseline Assumptions

The RVSM benefits analysis for U.S. air carriers that operate in the Pacific is predicated on several assumptions as listed below.

- RVSM approved aircraft fly at or above FL 310 through FL 390.
- Non-RVSM approved aircraft fly at or below FL 290 or at or above FL 410. Although other alternatives may be feasible on a case-by-case basis, the benefit analysis did not attempt to explore these options. In addition, there were no reality checks regarding the ability for a given aircraft type to have sufficient fuel capacity to fly the longer range

routes at the non-RVSM flight levels. These issues will be examined under a separate study.

- Track Generation/Advisory would operate as it currently does in Oakland. This means that the current flight entry levels employed by track generation would remain the same (i.e., Westbound: 280, 3 IO, 350, Eastbound 290, 330, 370).
- There would be no change to current capacity restraints identified in Facility Letters of Agreement.
- Wrong Altitude for Direction of Flight (WAFDOF) would continue to be used to tactically accommodate pilot requests and to separate traffic when these altitudes are available.
- A specific aircraft type is considered to be either 100 percent RVSM approved or 100 percent non-RVSM approved. In reality, this may not be the case since it is dependent on several factors including upgrade cost as well as pilot training. An aircraft type may be approved but is not operated by a crew that has been trained or certified for RVSM operations. Similarly, one U.S. air carrier may elect to have a particular aircraft type approved for RVSM while another may opt not to do so. However, for purposes of this analysis, if an approved RVSM service bulletin or the equivalent was available to upgrade a particular aircraft type, then the aircraft type was considered approved.
- 50 nmi Lateral Separation would be implemented in the CEP (i.e., no composite separation).
- In order to minimize the potential increase in controller workload, requests for climbs would remain at 2000 foot increments. This means that the number of climb requests should remain about the same and, if workload permits, the controller will grant 1000 foot step climbs in lieu of the 2000 foot climb. This assumption is based on an Informal Pacific ATC Coordinating Group (IPACG) statement regarding the application of RVSM implementation: "RVSM will be used for the primary purpose of eliminating the daily crossing problems with the secondary purpose of providing 1000 foot step climbs on routes or portions of routes that do not experience daily crossing situations".
- There should be no impact to ground delays, since the analysis assumes that Track Advisory is not affected by the implementation of RVSM.
- Approved RVSM aircraft types include:
- B747
- DC-IO

- 💣👎📫📂📂
- A310
- B747F
- A340
- B767
- A300
- A340
- B737
- B757
- B767
- C-130
- B727
- L-1011
- C-141
- B777
- c-5
- All military except as noted in non-RVSM approved
- All general aviation except as noted in non-RVSM approved

- Non-RVSM approved aircraft types include:
- KC-135
- c-135
- DC-8
- DC-9

Section 3

Results of Benefits Analysis

This section provides the results of the RVSM benefits analysis for U.S. air carriers that operate in the Pacific.

Table 3-1 provides a summary of the U.S. air carriers by aircraft type that were analyzed for the 7-day period.

Table 3-2 indicates that U.S. air carriers comprise an average of 44 percent of the total number of operations. Of the 1616 operations, Tables 3-3 and 3-4 indicate that 1595 were RVSM approved and 21 were non-RVSM approved. Although the minimum sample size needed for conducting the benefits analysis was determined to be seven days, it should be noted that this is a small sample of actual flight operations. Consequently, it most likely is not indicative of the variation in flight profiles, aircraft fleet mix, meteorological conditions, etc. While several flights had repeated improved performance over the 7-day sample, the actual benefits may vary.

Table 3-3 indicates that the projected RVSM benefit will average 35 gallons per flight. It is important to recognize that these projected benefits are based on the set of assumptions identified in Section 2.2 as well as the analysis approach described in Section 2.1. A change of assumptions or the analysis approach most likely will impact these quantitative results. For example, the analysis shows that speed and entry altitude changes were among the largest contributing factors to the benefits. Therefore, it is important that the RVSM benefits be presented in the context that they were derived.

In addition, the results in this table show a disproportionate penalty shared among the U.S. cargo carriers as compared to U.S. passenger carriers. A sensitivity analysis was performed for Federal Express, Polar Air Carrier, Ryan and United Parcel Express, adjusting downward the gross takeoff weights for these flights and comparing the benefits results. The results of the sensitivity analysis for a total of 20 flights over the seven days were mixed, with the flights operating at a reduced gross takeoff weight, realizing a net fuel benefit of 85 gallons. Two carriers, Federal Express and United Parcel realized a benefit from the reduced gross weight, while the other two carriers realized a larger penalty as compared to operating with the higher gross takeoff weight.

Table 3-l. Distribution of All U.S. Air Carriers by Aircraft Type Over a 7 Day Period

U.S. Air Carrier	Air Carrier Designator	B727	B737	B747	B74A	B74B	B757	B767	DC10	DC8	L101	M11	MD11	MD80	TOTAL
Alaska	ASA													3	3
Aloha Airlines	AAH		2												2
American Airlines	AAL						14		68			4	45		131
American International	CKS				11					5	3				19
American Trans Air	AMT						12				32				44
Continental Micronesia	CMI	79			40		91		9						219
Continental	COA				5				35						40
Delta Airlines	DAL										82	4	40		126
Evergreen International	BIA				13										13
Federal Express	FDX								7				56		63
Gemini Air Cargo	GCO								8						8
Atlas Air	GTI				1										1
Hawaiian	HAL								114						114
Northwest Airlines	NWA				132	32			111						275
Polar Air Cargo	PAC				6										6
Ryan	RYN	9							15		2				26
Sun country	SCX								11						11
Trans World	TWA						6	8							14
United Airlines	UAL			1	67	181	78		121						448
United Parcel	UPS				18		1	18		16					53

Service

TOTAL	88	2	1	293	213	202	26	499	21	119	8	141	3	1616

Table 3-2. Distribution of All Flights by Date Over a 7 Day Period

		10-May	18-May	25-May	10-Jul	22-Jul	23-Jul	25-Jul	Total
U.S Air Carriers	# of flights/day	228	229	206	244	252	210	247	1616
	% of flights/day	40%	43%	43%	47%	46%	47%	45%	44%
U.S. Military & General Aviation	# of flights/day	50	37	30	32	39	35	45	268
	% of flights/day	9%	7%	6%	6%	7%	8%	8%	7%
	# of flights/day	290	267	239	240	261	206	257	1760
Foreign Carriers	% of flights/day	51%	50%	50%	47%	47%	46%	47%	48%
Total	# of flights/day	568	533	475	516	552	451	549	3644

U.S. Carrier	Total Number of Flights	Total Number of Flights Receiving Additional 1000 ft Step Climbs	Total Number of Additional 1000 ft Step Climbs	Total Number of Flights Receiving Additional 2000 ft Step Climbs	Total Number of Additional 2000 ft Step Climbs	Fuel Saved / (Lost) Due to Step Climbs (gallons)	Time Saved / (Lost) Due to Step Climbs (minutes)	Fuel Saved / (Lost) Due to Other* (gallons)	Time Saved / (Lost) Due to Other* (minutes)	Total Fuel Saved / (Lost) (gallons)	Total Time Saved / (Lost) (minutes)	Avg Fuel Savings / (Loss) per Flight (gallons)
AAH	2											
AAL	131	43	48	0	0	1614	12	3547	29	5161	41	39
AMT	44	0	0	0	0	0	0	1521	55	1521	55	35
ASA	3											
CKS	14	3	3	0	0	126	(1)	122	7	248	6	18
CMI	219	32	37	0	0	1438	2	1600	16	3038	18	14
COA	40	13	17	2	3	1168	1	1837	6	3006	6	75
DAL	126	66	84	1	2	146	(2)	(203)	51	(57)	49	(0)
EIA	13	4	4	0	0	228	0	271	0	499	0	38
FDX	63	18	18	0	0	(184)	9	(1026)	0	(1210)	9	(19)
GCO	8	5	5	0	0	138	0	94	0	232	0	29
GTI	1											
HAL	114	31	31	0	0	1814	14	1406	(7)	3220	8	28
NWA	275	116	167	0	0	11979	17	3701	27	15680	43	57
PAC	6	2	2	0	0	(210)	0	0	0	(210)	0	(35)
RYN	26	10	12	0	0	315	5	(1131)	(12)	(816)	(6)	(31)
SCX	11	2	2	0	0	1	0	111	7	112	7	10
TWA	14	7	9	1	1	(93)	2	(116)	14	(209)	15	(15)
UAL	448	171	227	0	0	15341	44	11341	93	26682	137	60
UPS	37	8	8	0	0	(662)	0	0	0	(662)	0	(18)
TOTAL	1595	531	674	4	6	33158	102	23075	286	56233	388	35

Table 3-3. Breakdown of RVSM Benefits for All U.S. Air Carrier Approved Aircraft Over a 7 Day Period

* Fix Entry	Control Effects, Lower and Miscellaneous

While it is risky to interpret the results of the sensitivity analysis from such a small sample size, some contributory factors can be mentioned which will aid in the interpretation of the results for the total sample size. First, the tiled flight plan flight profile carry with them uncertainties at the time of flight planning [3], and cannot account for the uncertainties such as weather and ATC service along the route of flight. The planned climb points may be early or late by as much as a waypoint. As a side note, a quick analysis of the position reports for U.S. cargo carriers indicates that the flight plan altitudes are on average within 1000 feet of the altitude actually flown within the ZOA FIR. This analysis did not consider the actual portions of the flight outside of the U.S. FIR. When taken across a large enough sample size, these uncertainties, will tend to cancel out and the flight plans may represent a fairly accurate flight profile. When looking at the U.S. carriers that fly 100 or more flights per week, the benefit for RVSM is on par with that reported for the entire U.S. fleet. Second, the fuel bum analysis assumes that the primary consideration for each flight is minimizing fuel consumption. While flights operating well within their planned block times may optimize for fuel, flights that are delayed or otherwise time constrained may choose to trade fuel for minimum flight time. Time did not permit a sensitivity analysis of fuel bum versus mach speed nor an analysis of the distribution of actual flight speeds for various carriers along the same city pair routes.

Notwithstanding the results of sensitivity analysis, the overall result of the benefit analysis matches well with expectations from other operational data and rules of thumb. In today's Pacific operations, each flight requests on average 1.5 climbs, and 80 percent of climb requests are granted. Each denied climb request increases the fuel consumption by one per minute per 2000 feet of altitude denied. If the average flight length is 7 hours, and climbs are distributed along that flight length, a flight which is denied a climb would on average be flying 2000 feet lower than desirable for 3.5 hours. If 20 percent of the requested climbs were denied, an average loss of 64 gallons would be realized by each flight. If RVSM is only applies when a 2000-foot climb is denied, the flight would be expected to gain half of that loss back, allowing the aircraft to fly 1000 feet higher for that 3.5 hour period. RVSM should then be expected to provide a benefit of 32 gallons per flight on average. This number compares well with our benefits analysis result of 35 gallons per flight.

Table 3-4 indicates the impact on U.S. air carriers that operate non-RVSM approved aircraft. It appears that at least one U.S. cargo carrier will incur significant penalties if they continue to operate non-RVSM approved aircraft. In the pre-RVSM model run, these aircraft were flying at higher altitudes as filed in their flight plan. With RVSM, these aircraft were kept at FL 290 or below and as a result, incur a fuel penalty. In the real ATC environment with RVSM, an ATC controller may be able to assign a higher flight level, if traffic permits. However, for planning purposes, the flight plan of a non-approved RVSM aircraft cannot be tiled with this higher altitude. It should be noted that in some cases, cargo carriers may opt to incur a fuel penalty in order to meet their scheduled arrival time.

As previously mentioned, the results indicate that RVSM may provide an average fuel benefit of 35 gallons per flight. However, it is recognized that certain attributes of the model and input data have a direct affect on the projected fuel savings. For example, there were situations where non-approved aircraft may have blocked approved aircraft from climbing to their preferred'altitudes. This occurred for a small number of the flights (2 per day) that were operating at lower altitudes even though they were RVSM approved. Without intent information and suitable planning time available to the controllers, the flow of aircraft entering oceanic airspace cannot be optimized to enable RVSM altitude access for all the approved aircraft.

Due to errors in some of the ETMS and ODAPS SAR data, some flights had to be removed in the simulation. As a result, these omitted flights could have created additional conflict situations. In addition some of the input data contained erroneous or incomplete information and attempts were made to correct this information. However there is no way to validate whether these corrections were the same as the intended flight data.

Table 3-4. Summary of RVSM Benefits for All U.S. Air Carrier Non-Approved Aircraft Over a 7 Day Period

U.S. Carrier	Total Number of Flights	Fuel Saved I (Lost) (gallons)	Time Saved / (Lost) (minutes)	Average Fuel Saved / (Lost) (gallons)
CKS	5	0	0	0
UPS	16	(7210)	(2)	(450.6)
TOTAL	21	(7210)	(2)	(343.3)

While the data was based on actual, active flight plans, amendments to the flight plans were not taken into account by the model. It should be recognized that even if the model utilized these amendments, only ZOA data would be available. In addition, there would be no way to account for amendments that were marked only on the paper flight strip (i.e., not entered into ODAPS) or for changes that occurred outside the U.S. FIR. As more aircraft are approved, without the addition of new flight levels, the fuel benefit to approved aircraft will decrease. However, if a higher confidence in predictability is achieved, the benefits could increase if savings can be achieved by lowering crew costs. The most recent discussions regarding RVSM implementation for right-altitude-for-direction may increase the predictable minimum altitude achieved on westbound flights.

Uncertainties of transit time can be attributed to either errors in forecasted winds, entry sequences of aircraft with differing referred airspeeds, or ATC service. Assuming the wind factor will average out for opposite direction flights if the sample size is large, the entry configuration and the performance of ATC service are key drivers.

The fuel bum differences between RVSM and non-RVSM altitudes for a given aircraft type can vary by a factor of two to three depending on the input gross takeoff weight or planned flight profile. Preliminary error analysis indicates that as much as 30 percent of the flights may be modeled at heavier weights or higher profiles than may actually be flown.

Other concepts for the use of RVSM could provide different or additional benefits depending on the application of RVSM by the service provider and the flavors of benefits desired by the users. The benefit of predictability for the user could multiply the fuel savings ten fold as the flights could trade revenue cargo for predictable fuel savings. Block times would also be improved resulting in lower crew costs. The RVSM could also be used for better predictability of oceanic entry altitudes.

One alternative under investigation would be to alter the westbound altitudes to be even thousand foot intervals (e.g., 300, 320, 340, 360). The result would be that approximately 80 percent of the flights would be able to enter westbound at 1000 feet higher than was modeled. This is important because the dispatchers must assume a flat oceanic profile when fuel planning a flight, since climbs cannot be guaranteed in the ocean. The additional westbound entry altitudes would provide an average fuel savings of 60 gallons per flight. This would be an additive fuel benefit to the 35 gallons for a total savings of 95 gallons. It is important to note that the entry altitudes have not been determined at this time and that further analysis is needed to identify user preferences. This will be part of a subsequent analysis.

Finally, since the dispatcher must plan for one appropriate flight level above and below the ideal entry altitude, if RVSM were used to minimize the contingency altitude planning, for every 1000 feet from ideal, the average flight could save 2 IO gallons in planned fuel for a

7 hour flight. This is equivalent to approximately 120 gallons in actual fuel savings. This would be an additive fuel benefit to the 95 gallons for a total of 215 gallons. As a result, total fuel savings of 95 gallons per flight could be achieved when operating RVSM under this concept.

In summary, the results of the RVSM benefits analysis must be presented in the content that they were derived to ensure proper interpretation.

Section 4

Implementation Issues

The RVSM benefits analysis was based on an implementation scheme that has subsequently evolved and may not reflect the initial or final RVSM implementation. Based on the set of assumptions identified in Section 2.2, it appears that there will be a small RVSM fuel benefit. This appears to be a conservative estimate based on the set of assumptions and the preliminary error analysis. While this benefits analysis is needed to pursue Rulemaking, it is important that the specific implementation details be developed so that the impact to ATC operations as well as benefits can be assessed and evaluated prior to finalizing the detailed plans.

There are a number of alternative implementation strategies and issues as identified below, that need further analysis before deciding upon a specific implementation approach for Anchorage and Oakland.

- Whether to implement in particular geographical areas (e.g., NOPAC, CENPAC).
- Whether to track load by adding one, two, or three additional flight levels.
- Whether neighboring FIRs (e.g., Tokyo) would be able to accept more aircraft if track loading was implemented.
- Whether to implement by right altitude for direction of flight (i.e., westbound: even altitudes, and eastbound: odd altitudes).
- Whether there should be time limitations for RVSM application (e.g., consistent with NOPAC tracks).
- The development of ATC procedures to support contingency plans and phased implementation options.
- Potential impact on Track Advisory.
- Potential impact on current weather deviation procedures
- Development of policy/procedures regarding the handling of non-approved aircraft.
- Development of transition area procedures and analysis of the impact on controller workload.
- Effect of wake turbulence and impact on procedures.

The current plan is to discuss these strategies and issues with the sites and prioritize the order in which they will be further analyzed.

List of References

1. FAA, Strategic Plan for Oceanic Airspace Enhancements and Separation Reductions, September 1998, U.S. Department of Transportation, Federal Aviation Administration, Washington, DC.
2. CSCI, Washington, D.C., email note from Bob Miller on 18 December 1998 pertaining to work supporting Flight Standards Service (AFS-400).
3. Sanders, S., August *1998, In-Flight Flight Plan Re-Calculation*, MTR 98W0000100, The MITRE Corporation, Center for Advanced System Development (CAASD), McLean. VA.

Glossary

ARTCC	Air Route Traffic Control Centers
ATC	Air Traffic Control
ATM	Air Traffic Management
CAA	Civil Aviation Authority
CAASD	Center for Advanced Aviation System Development
CENPAC	Central Pacific
CEP	Central East Pacific Region
ETMS	Enhanced Traffic Management System
FAA	Federal Aviation Administration
FIR	Flight Information Region
FL	Flight Level
ICAO	International Civil Aviation Organization
IPACG	Informal Pacific ATC Coordinating Group
NAT	North Atlantic
NOPAC	North Pacific
ODAPS	Oceanic Display and Planning System
RNP-10	Required Navigation Performance-10
RVSM	Reduced Vertical Separation Minima

SAR	System Analysis Recording
SOPAC	South Pacific
WAFDOF	Wrong Altitude for Direction of Flight
ZAN	Anchorage ARTCC
ZOA	Oakland ARTCC